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# THE WEATHER AND CIRCULATION OF FEBRUARY 1969

## Strong Blocking Over North America for the Sixth Consecutive Month

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## 1. UNUSUAL WEATHER

This last month of winter produced or prolonged some of the season's worst weather. The most notable weather seemed to be directly related to widespread blocking, including the continued heavy precipitation in California. Some unusual mean weather records and monthly totals are shown in table 1. Rain and snow created new February records in the West; in New England several alltime snow records were established. The other extreme, lack of precipitation, caused record monthly dryness in Michigan and Wisconsin. This was the sunniest February of record at Sault Ste. Marie, Mich., and the least sunny at Huron, S. Dak., and Red Bluff, Calif. The addition of more snow in the upper Mississippi Valley, Utah, and the Sierra Nevada Mountains increased the threat of spring flooding and resulted in early warnings in some areas.

TABLE 1.—*Notable monthly precipitation totals in February 1969*

| City | Amount (in.) | Remarks |
|---|---|---|
| Boston, Mass. | 41.3 | Heaviest snowfall in any month |
| | 7.08 | Record February precipitation |
| Concord, N.H. | 49.8 | Heaviest snowfall in any month |
| | 13.8 | Heaviest 24-hr snowfall |
| Portland, Maine | 61.2 | Heaviest snowfall in any month |
| Bismarck, N. Dak. | 17.4 | Heaviest snowfall in 47 yr |
| Norfolk, Nebr. | 19.1 | Heaviest snowfall in 33 yr |
| Salt Lake City, Utah | 27.9 | 294% of normal February snowfall |
| Ely, Nev. | 2.19 | Wettest February of record |
| Hilo, Hawaii | 43.66 | Record February precipitation |
| Fresno, Calif. | | 17 days with precipitation, February record |
| Stockton, Calif. | | 18 days with precipitation, February record |

## 2. MONTHLY MEAN CIRCULATION

Strong blocking continued to dominate the 700-mb circulation over the United States and Canada this month. Other areas affected by blocking include the North Atlantic, Europe, and most of Asia. Some degree of high-latitude blocking occurred each month since the summer of 1968 in the Northern Hemisphere and over North America since September 1968.

Figure 1 shows the mean 700-mb circulation and figure 2 the mean 700-mb height anomaly for February 1969. The Aleutian Low was divided with one center over the Sea of Okhotsk and another center in the Bering Sea. This occurred with the return of strong westerlies and a predominantly zonal flow in the western and central Pacific. In January the Aleutian Low was in the Sea of Okhotsk, and a strong ridge of more than 150 m above normal was over Alaska. From January to February, height anomaly changes (fig. 3) decreased by as much as 250 m near Kodiak Island.

The 700-mb Low that was north of Hawaii last month was replaced by a ridge in February as anomalous heights increased by more than 100 m. This Low and the associated abnormal cyclonic activity moved eastward into the trough already along the west coast of North America. This trough was then more than 100 m below normal, the deepest relative to normal in the Northern Hemisphere this month. Heavy precipitation in the West Coast States resulted from this deep trough with 2 in. or more each week of February. This trough also contributed to ridging downstream as heights increased 60 m over Alberta. These increases extended the effects of blocking as above-normal heights spread from a center of 160 m near southern Greenland to a new center of 120 m over Hudson Bay.

Over the United States, 700-mb heights were below normal in the West, above normal in the upper Mississippi Valley, and below normal from southern New England to the Gulf of Mexico. Westerly flow strengthened in lower latitudes as blocking forced the maximum westerly belt (fig. 4) far to the south. This resulted in the principal storm track farther south than usual (see Environmental Data Service, 1969*a*. Storms in the Atlantic also moved on a track much farther south than normal.

A mean surface Low about 5 mb below normal occurred near the 700-mb height anomaly in the western Atlantic. The flow associated with this vortex and the deep upper trough generally determined the weather for the eastern one-third of the Nation.

In the eastern Atlantic, a new surge of height rises of more than 100 m developed as a ridge replaced last month's trough. This resulted in height decreases over western Europe, a southerly storm track, and general exposure of western Europe to maritime Polar air masses.

Another lobe of high-latitude blocking affected Europe and Asia. This was as an axis of positive height anomaly from the Caspian Sea to the Polar regions then eastward to eastern Siberia. To the south in Asia, heights were below normal, westerlies were south of normal, and 1000–700-mb thickness was more than 170 m below normal. These factors suggest monthly mean surface temperatures well below normal over most of Siberia.

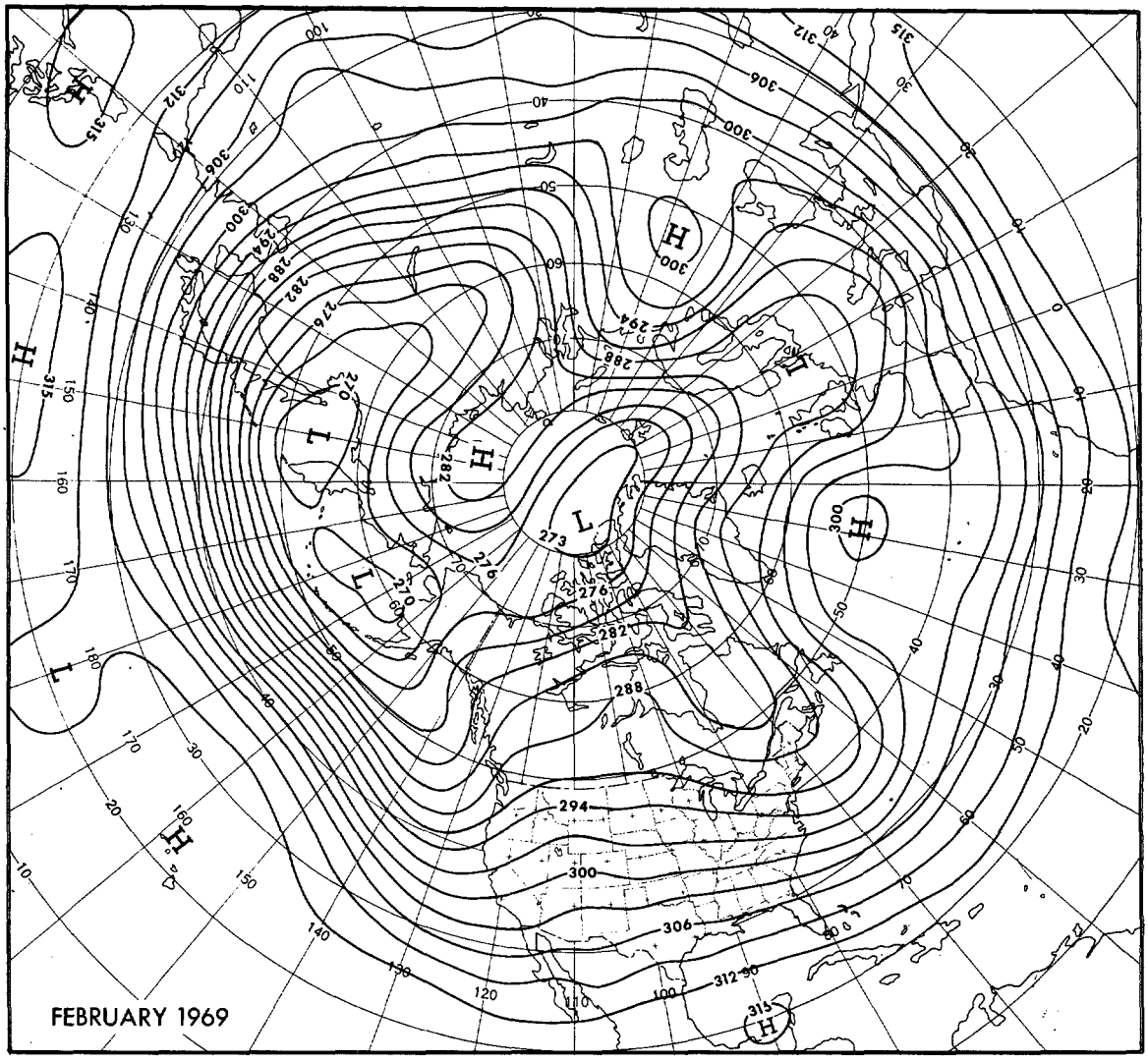


FIGURE 1.—Mean 700-mb contours (decameters) for February 1969.

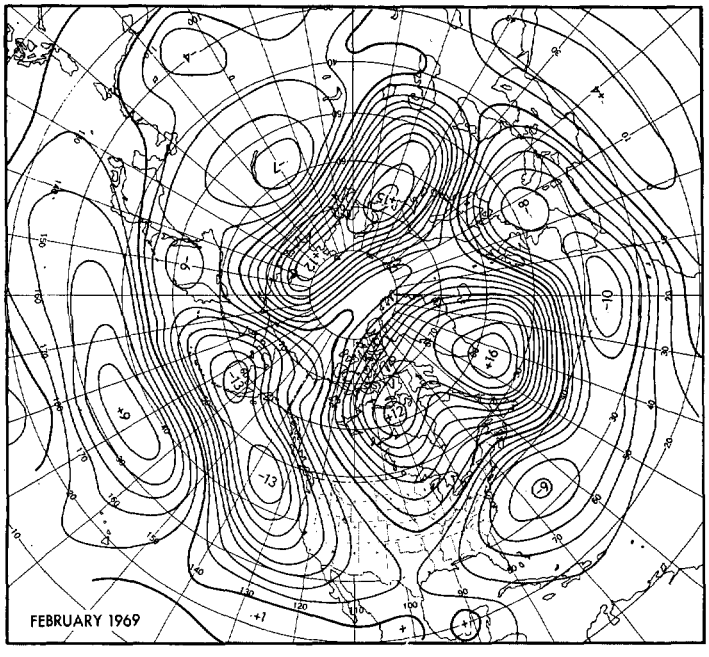


FIGURE 2.—Departure from normal of mean 700-mb height (decameters) for February 1969.

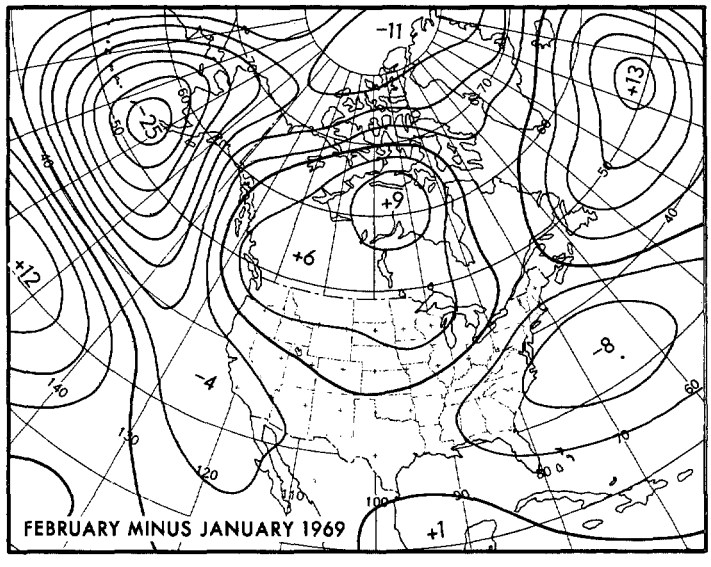


FIGURE 3.—Mean 700-mb height anomaly change (decameters) from January to February 1969.

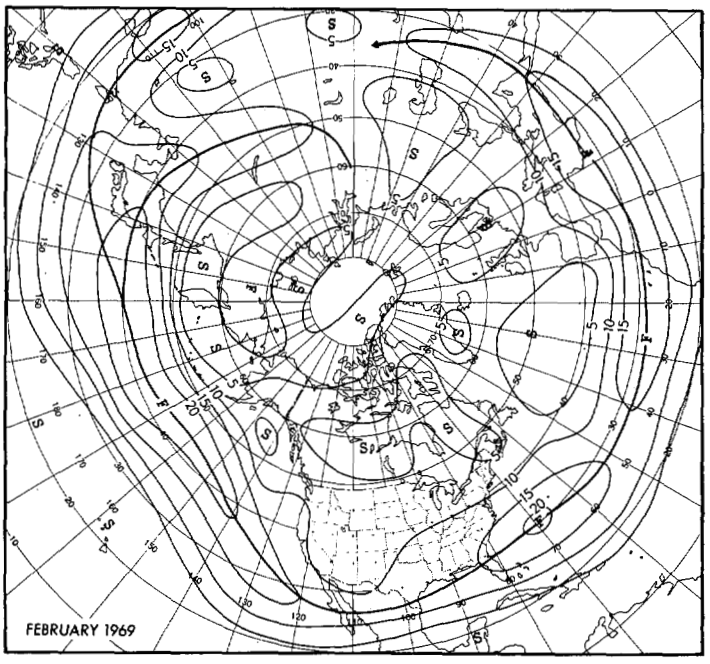


FIGURE 4.—Mean 700-mb wind speed (meters per second) for February 1969. Heavy solid lines show axes of maximum wind speed.

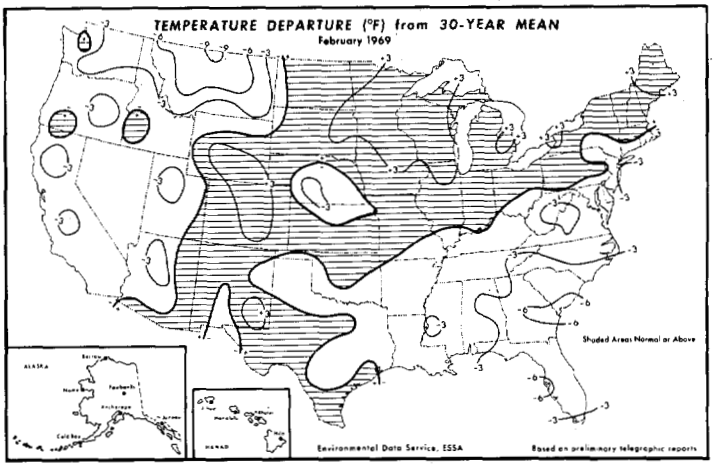


FIGURE 5.—Departure from normal of average surface temperature (°F) for February 1969 (from Environmental Data Service, 1969*b*).

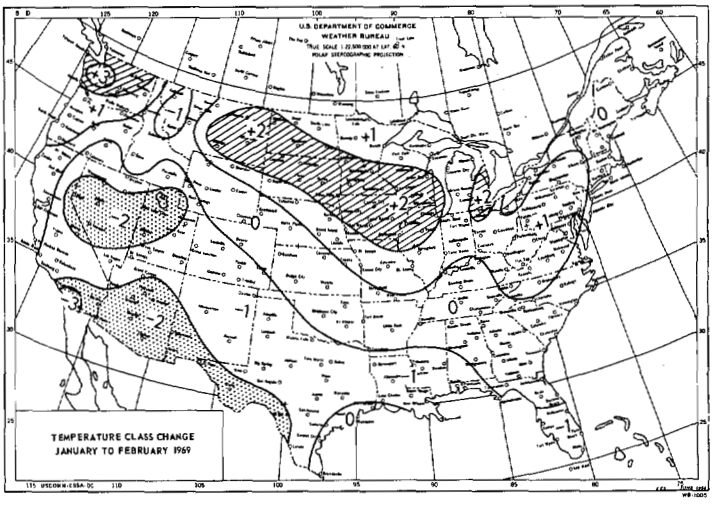


FIGURE 6.—Monthly mean temperature class change from January to February 1969.

Slight increases in 700-mb anomalous heights this month along the Asian coast resulted as the flow became less meridional. In this area and across the Pacific, westerlies shifted northward. Wind speeds were more than 10 m $sec^{-1}$ stronger than normal, and the west wind maximum (fig. 4) was 10–15° latitude north of normal. In spite of the strength of this flow, the monthly mean index (35–55° N.) in the western portion of the Northern Hemisphere averaged 1.8 m $sec^{-1}$ below normal. Most of this resulted from the strong easterly anomalous flow from the western United States to western Europe. The strong westerly flow in the Atlantic was too far south to affect the temperate index, but it caused the subtropical westerly index to average 1.6 m $sec^{-1}$ above normal.

## 3. MONTHLY MEAN WEATHER

### TEMPERATURE

Anomalous temperatures this month (fig. 5) seemed well related to the mean 700-mb height anomaly (fig. 2). Over most of the West, heights were below normal, even into the ridge over the Rockies, and temperatures responded and became below normal. Temperatures ranged to 3°F below normal over most of the area except in Montana (6°–9°F below normal) where quite cold weather persisted all month. In the Southeast, temperature and heights also averaged below normal with the coldest areas 3°–6°F below normal.

Above-normal temperatures from the northern Mississippi Valley to New England generally paralleled above-normal heights. This month only two surface Highs moved across the Northeast, and only one of those produced appreciable though temporary cooling. Had the snow cover been less in this area, the dominant maritime flow would have produced milder weather. Preliminary reports show no new temperature records this month, which was consistent with the absence of large height anomalies and the predominant maritime flow in the Nation.

Temperature persistence from January to February 1969 amounted to 79 out of 100 cities with changes of no more than one class (unshaded areas of fig. 6). Most of the change was two classes warmer in the Northern Plains and two classes cooler in the Great Basin and parts of the Southwest. These changes reflect the expansion of blocking this month.

### PRECIPITATION

Two to three times normal precipitation fell over California and most of the Great Basin; in a narrow channel from northwestern Texas to North Dakota; and in most of New England (fig. 7A).

Coastal areas of the West Coast States and interior mountain ranges received more than 8 in. of precipitation this month (fig. 7B). This was considerably less than the record-breaking precipitation of January which was generated by the long southwesterly fetch from the subtropics of the eastern North Pacific. In February, heavy rains

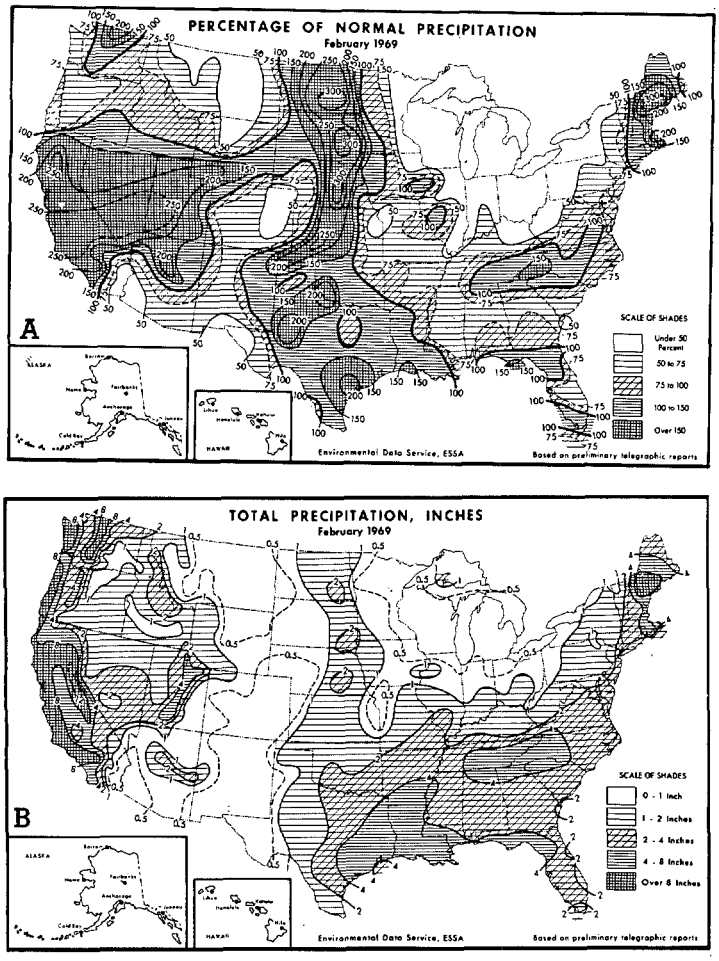


FIGURE 7.—(A) percentage of normal precipitation (inches) for February 1969; (B) total precipitation (inches) for February (both from Environmental Data Service, 1969*b*).

and heavy snow resulted from the deep trough along the west coast.

The upper level flow (fig. 1), displaced far to the south over the United States and northern Mexico, produced a surface storm track across the lower one-half of the United States (Environmental Data Service, 1969*a*). Storms that deepened off the west coast regenerated in the lee of the southern Rockies and especially in the Texas Panhandle. These storms produced heavy precipitation in the Plains States including monthly snowfall of 19 in. at Norfolk, Nebr., and 17 in. at Bismarck, N. Dak.

Two to 4 in. of precipitation fell over the Gulf Coast States and the Southeast. This was generally normal or less. Two severe snowstorms resulted in record snowfall and precipitation in several localities in New England. Water content was 4–8 in. or two to three times normal. In States near the Great Lakes, less than one-half inch of precipitation fell. This created new records for least monthly precipitation in several cities (table 2), a result of the strongly anticyclonic anomalous flow and lack of surface storms.

Additional heavy snowfall during February increased the already heavy snowpack in the mountains of southern California, Utah, in the upper Mississippi Valley, and in New England. This increased the threat of spring flooding

TABLE 2.—*Lightest February precipitation of record*

| City | Amount (in.) |
|---|---|
| Waterloo, Iowa | .02 |
| Rockford, Ill. | .04 |
| Green Bay, Wis. | .04 |
| Milwaukee, Wis. | .05 |
| Detroit, Mich. | .15 |
| Alpena, Mich. | .34 |

in most of these areas. In Minnesota, the water content of the snow averaged more than 5 in. across the State and 7–9 in. in northwestern counties. The circulation and snowpack this season in this area were similar to the preflood conditions in the spring of 1965.

## 4. WEEKLY WEATHER AND CIRCULATION

### FEBRUARY 3–9

Troughs and ridges at 700 mb (fig. 8A) moved fast this week, and blocking strengthened in eastern North America. The Low that was in the Bering Sea last week moved into the Gulf of Alaska, and the trough associated with it deepened southeastward along the west coast of North America. This forced the ridge from the Gulf of Alaska into a favored location along the Rocky Mountains. Meanwhile the trough that dominated the eastern half of the Nation was now in the western Atlantic. Strong deepening to more than 180 m below normal occurred near the Maritime Provinces as a blocking ridge extended from the eastern Atlantic to Baffin Island.

Temperatures averaged above normal over most of the South and South-Central States this week (fig. 8B) and in the lee of the Rockies where downslope warming helped raise temperatures to 6°–9°F above normal. The widespread warming occurred as a daily upper level ridge crossed the Nation. Temperatures were a few degrees below normal in the Northern Border States and in most of the West where below-normal heights prevailed except in the Dakotas.

Precipitation this week (fig. 8C) was heavy from northern California to the Canadian border and in New England. The first major storm of the week deepened in the eastern Great Lakes on Monday and became a severe storm in the Maritime Provinces on Tuesday. This storm brought heavy snow to the Great Lakes snow belt (29 in. at Boonville, N.Y.) and New England. As this storm passed through the Middle Atlantic and Southern States, precipitation amounted to less than 1 in.

Late in the week, a vigorous storm associated with a fast-moving short-wave trough caused heavy snow in the central Rocky Mountains. The storm moved eastward at more than 30 kt and deepened off the Virginia capes. From this storm, called one of the worst in a decade in New England, snowfall totaled 10–20 in. generally, but more than 3 ft in some suburban areas (see following subsection and table 3).

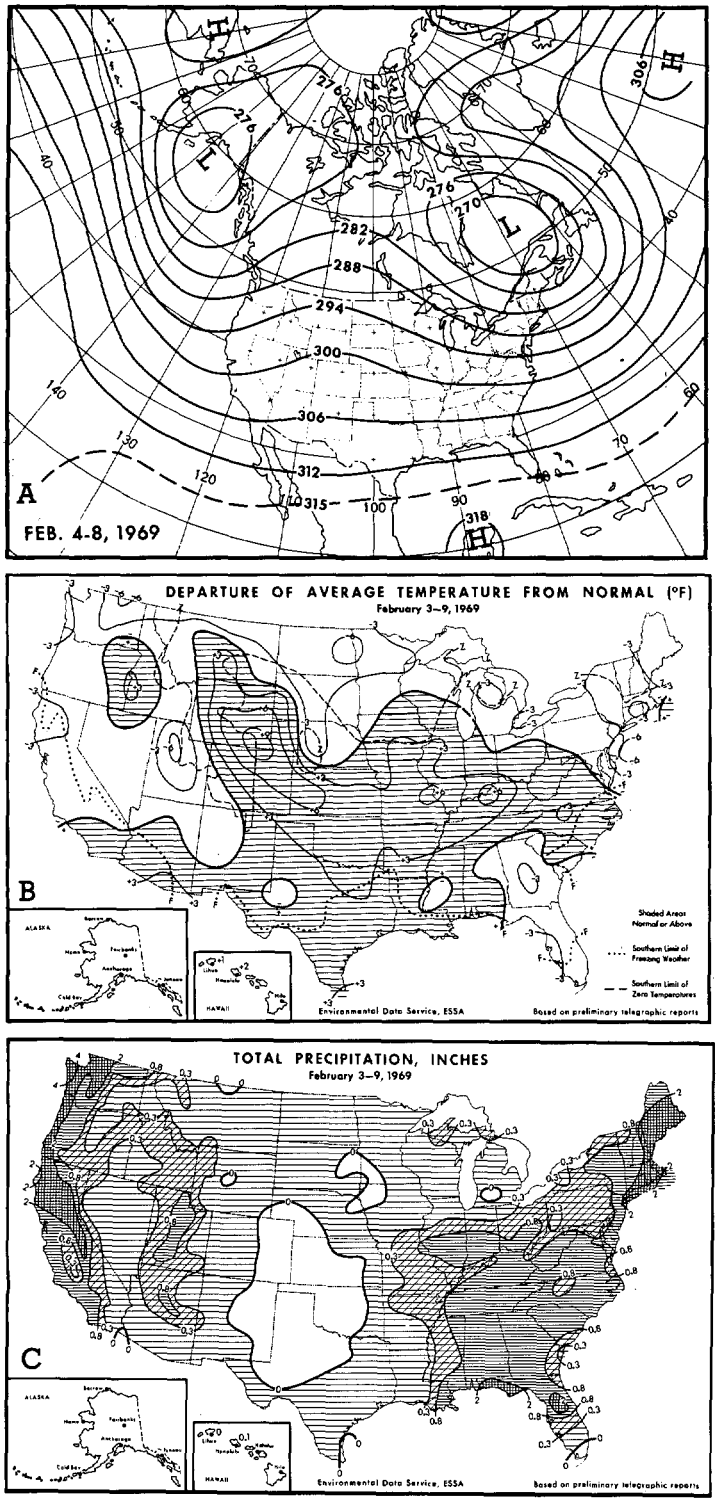


FIGURE 8.—(A) mean 700-mb contours (decameters) for Feb. 4–8, 1969; (B) departure from normal of average surface temperature (°F) for Feb. 3–9, 1969; (C) total precipitation (inches) for Feb. 3–9, 1969 (B and C from Environmental Data Service, 1969*b*).

TABLE 3.—*Total snowfall (inches) for two major storms in the Northeast in February 1969*

| City | Dates | |
|---|---|---|
| | 9–10 | 24–26 |
| | (in.) | (in.) |
| Boston, Mass. | 11 | 26 |
| Blue Hill, Mass. | 21 | 38 |
| Hartford, Conn. | 16 | 11 |
| New Haven, Conn. | 15 | 5 |
| Providence, R.I. | 10 | 16 |
| Mt. Washington, N.H. | 42 | 85 |
| Concord, N.H. | 14 | 22 |
| Portland, Maine | 22 | 26 |

## FEBRUARY 10–16

Widespread blocking contributed to a very steep decline in the 5-day mean 700-mb temperate westerly index this week. The index dropped to 6.2 m $sec^{-1}$ (3.3 m $sec^{-1}$ lower than normal) from a high of 11.0 m $sec^{-1}$ at the beginning of February.

Blocking spread westward (fig. 9A) and affected the western portion of the Northern Hemisphere. The mid-Pacific ridge of last week weakened as the strong Low over the Sea of Okhotsk moved into the Aleutians. With 700-mb heights above normal in the Arctic, the westerlies were displaced south of normal and the eastern portion of the Aleutian Low off the west coast of Canada remained deep.

A channel of below-normal heights developed from southern California to the Gulf of Mexico and northeastward to the New England coast. This channel suggests the southward displacement of the west wind maximum and surface storms.

Heights increased from southern Greenland to central Canada, and the trough along the east coast moved little as a short wave moved in from the west and redeepened the trough.

The surface storm that hit New England on Sunday worsened as it deepened to about 970 mb on Monday. This caused strong, gusty winds, blowing snow, and drifts to 6–8 ft in southern New England. Most traffic and commerce halted on Monday with a return to near-normal conditions only after several days. The Boston Parks Department reported tree damage from the combined effects of heavy snow and strong winds as being the worst in 45 yr, and the Massachusetts State Government spent $2 million on account of the storm.

The next storm moved across the Great Lakes and was followed by strong ridging in the central United States. This caused a strong transport of cold air into the eastern half of the Nation (fig. 9B) with temperatures 6°–9°F below normal in the Southeast. Freezing temperatures reached near the Gulf Coast and into north-central Florida. Most of the West warmed with maximum departures still in the lee of the Rockies.

Heavy rain fell in California and coastal areas of Washington and Oregon (9C), and heavy snow fell in mountain areas of these States. A west coast storm accompanied by heavy snow moved into the central Rockies by midweek, but the major upper level support for this storm stayed to the south and caused redevelopment at the surface near the Texas coast. This storm then went south of the strong cold ridge over the Great Lakes and caused heavy rain along the Gulf Coast and heavy snow from the Central Plains to Minnesota. Moderate to heavy

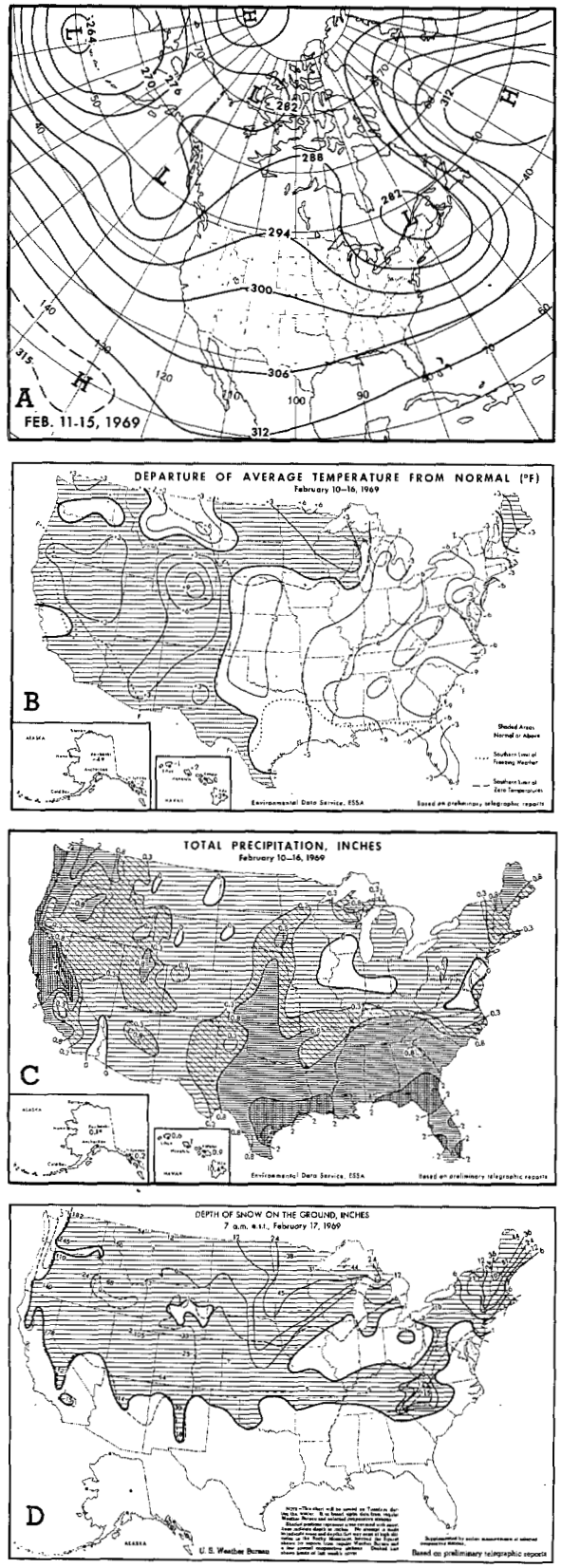


FIGURE 9.—Same as figure 8 except (A) for Feb. 11–15, 1969; (B) and (C) for Feb. 10–16, 1969; (D) snow on the ground (inches) for Feb. 17, 1969 (from Environmental Data Service, 1969*b*).

snow also fell from southern Kansas to the southern Appalachians. North Carolina reported 1–15 in. through the Piedmont and 6–18 in. in the mountains. By the end of the week, snow covered most of the northern three-fourths of the Nation (fig. 9D).

Another storm late in the week struck the West Coast States and spread heavy precipitation, mostly snow, into the Plateau.

### FEBRUARY 17–23

Principal 700-mb features in the westerly flow in lower middle latitudes (fig. 10A) progressed this week. The trough that was in the eastern Pacific last week appeared over California with heights more than 100 m below normal. The ridge in the Plains flattened and moved to the Ohio Valley, and the trough to its east drifted eastward slightly. Blocking persisted and spread westward. Heights decreased in eastern Canada to about 250 m above normal and increased over all of western Canada with a center near Hudson Bay now more than 200 m above normal. The 700-mb Low that was over New England last week redeveloped 900 mi southeastward with heights as much as 180 m below normal. The index remained at 6.2 m $sec^{-1}$ with westerlies still far south of normal. A northerly branch of the westerlies became established with strong flow in the Northwest Territories.

Temperatures increased from the Northern Plains to New England this week (fig. 10B) with maximum departures of 6°–9°F above normal from the Dakotas to the central Great Lakes and up to 6°–12°F above normal in northern New England. This mildness occurred as above-normal heights associated with blocking spread southward into the United States. Below-normal temperatures covered most of the rest of the Nation. Negative departures from normal were generally 3°–6°F except in Montana where they averaged 5°–15°F.

Surface activity this week seemed much like last week. An extensive, slowly moving Polar ridge dominated the eastern half of the United States. A strong Low entered the West and caused more than 2 in. of precipitation (fig. 10C) in central and southern California and increased the snowpack by several inches over the Sierra Nevada Mountains.

A short-lived Colorado Low again caused transport of warm, moist Gulf air northward which resulted in more snow from the Central Plains northward. A wave formed along the Texas coast and produced 1–2 in. of rainfall from Arkansas to the Gulf Coast and lesser amounts from there to the Middle Atlantic States. Snowfall in the East with this storm this week amounted to 1–3 in. from Washington, D.C., to New York City.

### FEBRUARY 24–MARCH 2

Major daily upper level features continued to travel fast this week (fig. 11A). Westerlies remained strong, but the temperate-latitude index reached a low for the month (5.7 m $sec^{-1}$, 3.4 m $sec^{-1}$ below normal) because much of the fast flow was in the subtropical belt south of 35° N.

In the Pacific, the Aleutian Low remained deep and nearly stationary. Small-scale perturbations from this major Low moved southeastward and reinforced the mean Low and trough along the west coast, somewhat farther west of its location last week. The High formerly over

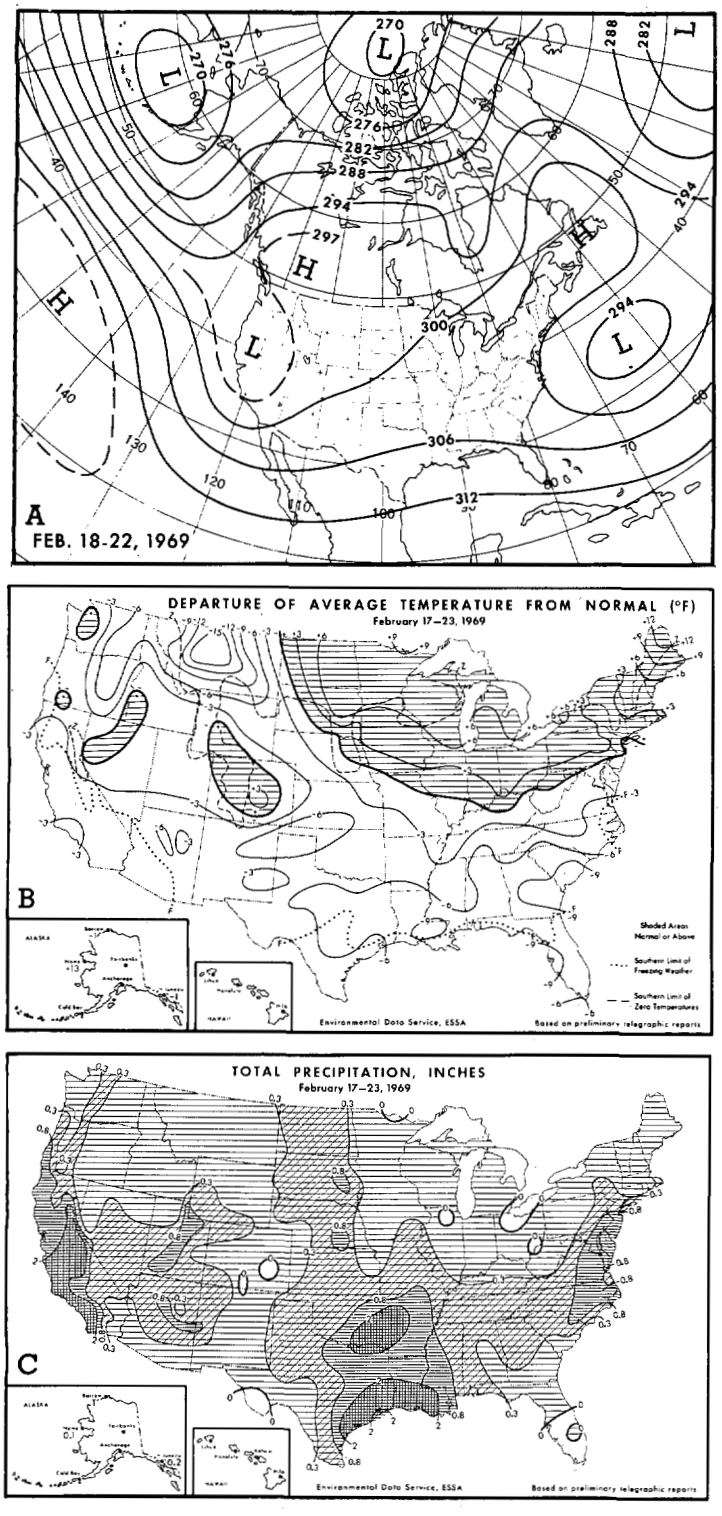


FIGURE 10.—Same as figure 8 except (A) for Feb. 18–22, 1969; (B) and (C) for Feb. 17–23, 1969.

Newfoundland reappeared west of James Bay with heights more than 200 m above normal. The Low off the east coast was forced to the mid-Atlantic and was replaced by a similar deep Low just east of Nantucket, Mass.

Above-normal temperatures (fig. 11B) continued from New England to the Northern Plains and spread to Texas with maximum departures of 9°–12°F in Minnesota and Wisconsin. The Southeast remained 3°–6°F below normal, and most of the west cooled further with temperatures 6°–9°F below normal over the Great Basin and 15°–20°F below normal in central Montana.

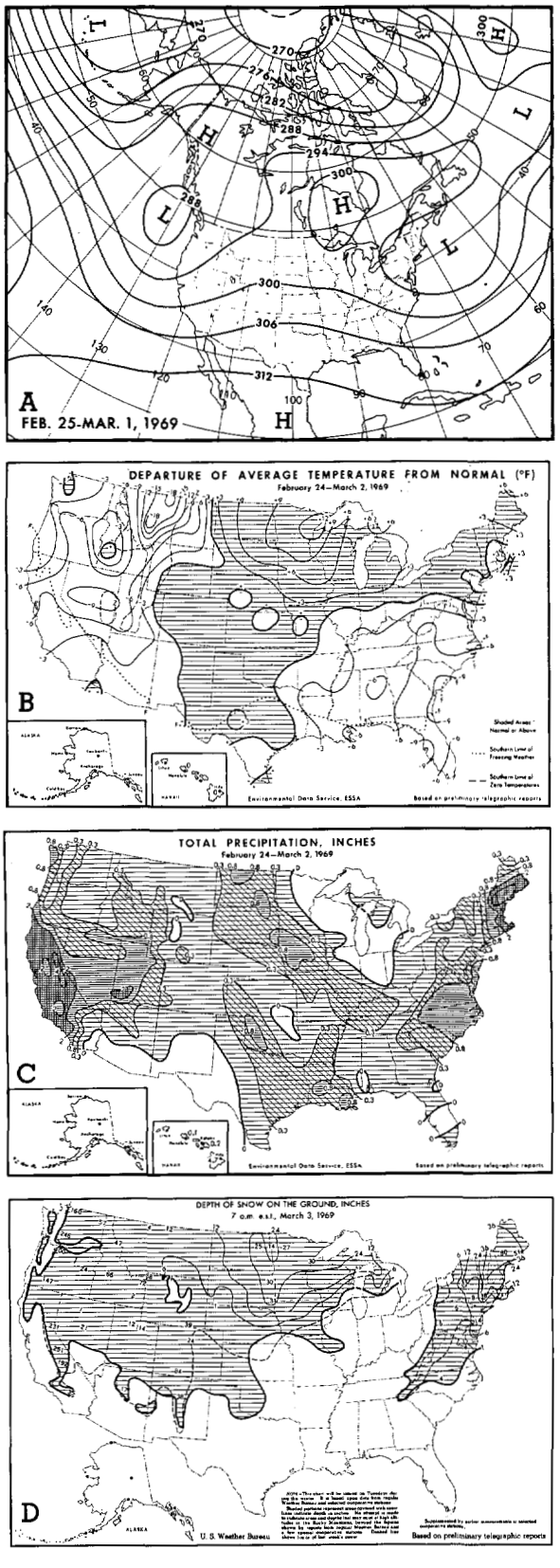


FIGURE 11.—Same as figure 9 except (A) Feb. 25–Mar. 1, 1969; (B) and (C) Feb. 24–Mar. 2, 1969; (D) for Mar. 3, 1969.

Precipitation (fig. 11C) was heavy over most of California and the Great Basin with 2–4 in. in most of California including 2–3 ft of new snow added to the near-record snowpack. The central and southern Sierras then had two and one-half to three times normal precipitation for February.

Early in the week, the Low off the Middle Atlantic States deepened as it headed toward the New England coast. This deep Low brought a new snowstorm that lasted most of 5 days in some areas and dropped 1–2 ft of new snow. This prolonged storm caused an estimated $150 million damage in Massachusetts alone and produced new record snowfall in many places including Boston, Mass., Portland, Maine, St. Johnsburg, Vt., and Woodstock, N.H. (table 3).

Meanwhile, another storm entered the West, crossed the Rockies, and then reformed in Kansas. This storm produced widespread precipitation, mostly snow, after reaching higher elevations in the West. The storm then traveled eastward to the Carolinas and brought rain to the South and snow from the western Carolinas to Pennsylvania. Near the weekend, still another storm crossed into the West and spread precipitation from California to the Central Plains.

## 5. WINTER 1968–1969

Blocking overwhelmed the 700-mb circulation over most of the Northern Hemisphere during the winter of 1968–1969. The general circulation over North America and nearby ocean areas consisted of a deep trough off the west coast, a channel of negative heights across the southern half of the Nation, and the deeper than normal trough off the east coast. This circulation resembled the February circulation most but was characteristic of all the winter months.

This winter's flow was similar to that of the winters of 1955–1956 and 1965–1966, but it was more intense. The positive height anomaly over Greenland and the negative anomaly off the Washington coast each amounted to at least three standard deviations.

Winter temperatures (fig. 12B) averaged 6°–15°F below normal from eastern Washington to western North Dakota and 4°–6°F below normal into the Central Plains. This was the coldest winter since records began in the 1870's at Great Falls, Havre, Cut Bank, and Lewiston, Mont. In the Southeast, negative departures were generally 2°–4°F while Maine had positive departures of 2°–4°F. Otherwise, temperatures across the Nation were near normal.

Normal precipitation fell over the eastern one-third of the Nation (fig. 12C) as totals ranged from 8–15 in. In the Northern Plains States and upper Mississippi Valley, one and one-half to two and one-half times normal precipitation fell mostly as snow, although total water content averaged 2–6 in. Sioux Falls, S. Dak., reported its greatest seasonal snowfall (92 in.). Precipitation in the West Coast States amounted to 16–32 in. which was two to two and one-half times normal over southern California and southern Nevada. This precipitation accounted for above-normal snowpack in the Cascades and the Sierra Nevada Mountains and at least one snowfall record (Mt. Shasta, Calif.) and one rainfall record (Los Angeles Civic Center).

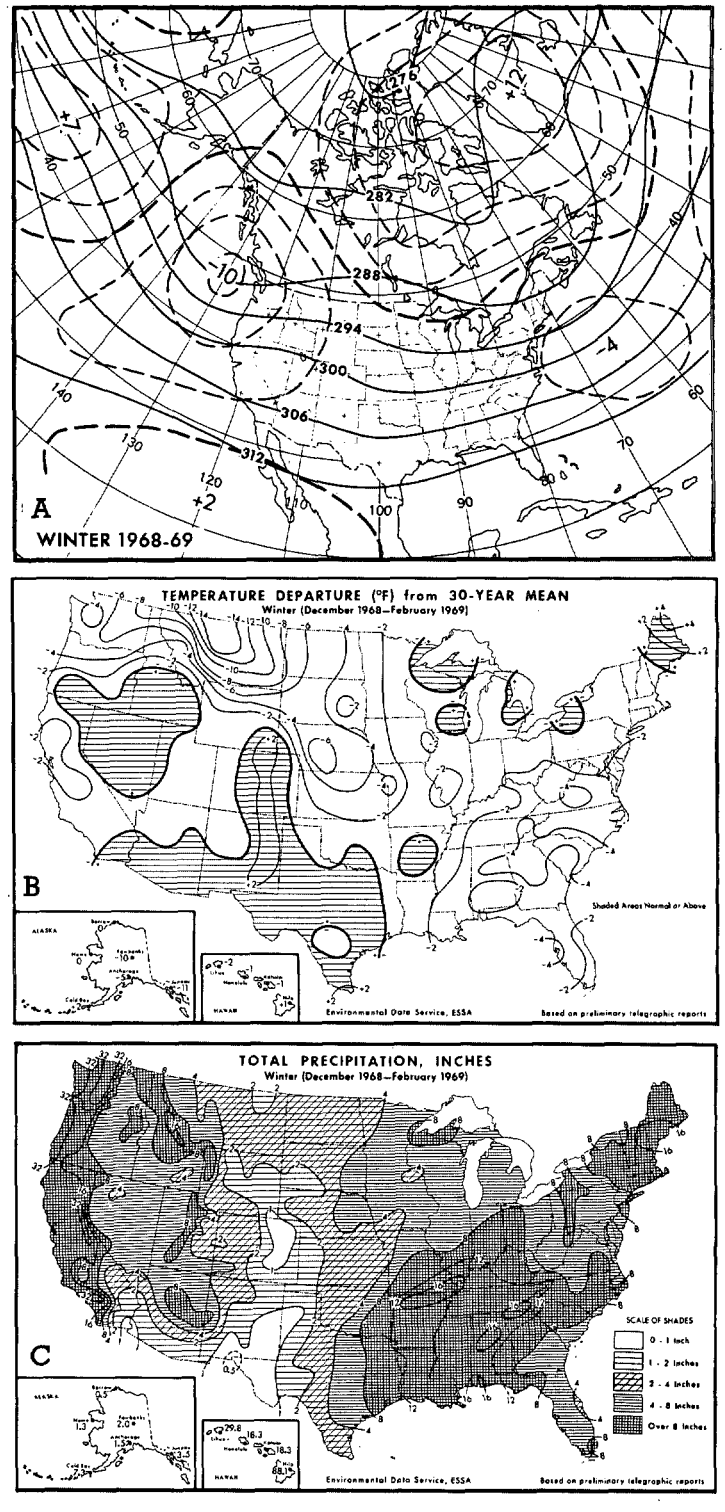


FIGURE 12.—Winter 1968–1969 (December, January, and February); (A) mean 700-mb contours (solid) and departure from normal of mean 700-mb height (dashed) (both in decameters); (B) departure from normal of average surface temperature (°F); (C) total precipitation (inches) (B and C from Environmental Data Service, 1969*b*).

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